GOVERNMENT OF ALBERTA

Alberta Energy and Utilities Board

Pre-Consultation Backgrounder

NATURAL GAS IN COAL

INTRODUCTION

As conventional natural gas reserves decline, interest in developing Natural Gas in Coal (NGC), also referred to as Coalbed Methane, is growing. *

NGC is gas that is attached (or "adsorbed") to coal seams, not trapped in the pore space of rock like most conventional natural gas. It is considered "sweet" gas, and is near-pipeline quality when produced, so it does not typically require extensive processing.

The development of gas in coal seams is subject to the same drilling, production and operations regulation as other natural gas activity. There are also rules in place to address water use and surface disturbance issues.

Five provincial government departments and the Alberta Energy and Utilities Board (EUB) are working together to review current legislation, policies and guidelines to determine if changes are required for NGC development. The Department of Alberta Energy is leading this initiative. The partners involved in this review include:

- Agriculture, Food and Rural Development
- Energy
- Energy and Utilities Board
- Environment
- Innovation and Science
- Sustainable Resource Development

* *The Alberta Energy and Utilities Board (EUB) uses the term Coalbed Methane.*

REGULATORY PROCESS

All energy developments impact the local area, surrounding environment and nearby public to some degree. Achieving a balance between responsible development and environmental protection is important.

The EUB is the lead regulator for energy development in Alberta. In addition, Alberta Environment is charged with regulating water and Alberta Sustainable Resource Development manages all public land. The Special Areas Board administers some portions of southeastern Alberta. Where a project involves one or more Special Area, this Board is consulted.

In Alberta, regulatory processes for review and approval of energy developments include:

- EUB technical standards and requirements,
- provincial standards established by Government of Alberta departments,
- environmental assessments for identified sensitive areas,
- multi-stakeholder reviews to ensure continued relevancy of regulations,
- use of broad Integrated Resource Management plans and strategies, and Integrated Landscape Management to guide development in select areas,
- application reviews to examine the merits of individual projects,
- the right of the public, who may be directly and adversely affected, to learn the facts, ask questions and have input into decisions,
- decision-making that is fair, science-based and considers the public interest,

- dispute resolution to address disagreements between development proponents, landowners and the public,
- public hearings for decisions with unresolved objections from parties that may be directly and adversely affected,
- surveillance and enforcement of approved development, and
- final reclamation requirements for energy development sites and public liability protection under the Orphan Well Program and the Liability Management Program.

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COAL DEPOSITS AND NGC IN ALBERTA

Coal Distribution

Alberta has vast amounts of coal distributed throughout the central and southern Plains, Foothills and Mountains. Millions of years ago, great thicknesses of plant matter accumulated in peat swamps. Over time, the plant matter was buried and gradually changed into coal through the increasing heat and pressure of burial. Coal-bearing rock formations now gently dip westward across the Plains toward the Mountains, where the coal seams abruptly turn toward the surface and are again exposed in the Foothills.

In Alberta, older coals are overlain by progressively younger coals, except in some locations within the Foothills and Mountains where older coals may be thrust over younger coals by mountain-building processes (see Figure 1 on page 3). Uplift and erosion of the west-dipping coals of the Plains has resulted in the present-day distribution of younger coals coming to the surface at locations farther west than older coals. Commonly, mines are located where the coal comes to surface.

The EUB estimates there are 91 billion tonnes of coal resources at depths suitable for mining. There are an additional 2 trillion tonnes of coal at depths in the Alberta Plains that may be suited for NGC exploration. Coal deposits in the Foothills and Mountains would significantly add to this tonnage.

Comparisons have been made between the Alberta coal basin and some of the highly productive NGC basins in the United States (e.g., San Juan and Powder River basins). Many American basins are much smaller and geologically constrained, with very thick coal seams that may be major aquifers.

Alberta coals tend to be thinner, of much greater extent and of a different composition. Even within the Alberta basin, different coal seams and zones have very different compositions, gas contents, water contents and production characteristics. Every NGC play is unique, and comparisons between coal basins or individual seams are difficult and often impractical.

Coal Occurrence in Alberta

In Alberta, coal typically occurs within a "coal zone" as discrete coal seams and/or packages with several thin and thick seams interbedded with non-coal rock layers or beds. A coal zone may be traceable over a large geographic area, even if the individual coals do not correlate very well. Coal zones are found in rocks ranging in age from late Jurassic (approximately 145 million years old) to Tertiary (approximately 65 million years old).

Many coal seams in Alberta can be physically traced over wide distances, but some of the thicker seams are quite complex in their distribution. Most of the coal zones in Alberta have potential as NGC exploration targets (see Figure 2 on page 7).

Zones

Many rock formations within Alberta contain coal seams. However, other than the zones listed below, most formations do not have coals sufficiently thick or continuous to produce gas.

Alberta Plains

The oldest and deepest coals of the Alberta Plains belong to the Mannville Coal Zone. Mannville coals are thick, continuous and contain some of the highest gas contents of any coals in the Alberta Plains. Typically, six or more seams contribute to total coal thickness ranging from two to 14 metres.

The thickest coals extend from southeast of Grande Prairie in a widening wedge between Edmonton and Calgary to the Coronation area, with coals occurring at depths ranging from about 800 metres up to 2800 metres in depth. Mannville coals are a NGC target throughout much of Alberta.

Three major rock packages containing coal zones overlie the Mannville Coal Zones. The Belly River Coal Zones (McKay, Taber and Lethbridge) are thinner and have a more limited distribution compared to the Mannville coal zone. These coals are distributed throughout central and south-central Alberta, and have not received much NGC exploration attention to date. The one exception is where the Lethbridge Coal Zone occurs close to other zones discussed below.

The Drumheller Coal Zone of the Horseshoe Canyon Formation, which occurs above the Belly River Coal Zones, has received considerable attention for NGC exploration. In the area between Bashaw and Rockyford, the Drumheller coal zone is relatively shallow (about 300 to 600 metres). The total coal thickness ranges from 10 to 20 metres. The coal zone may contain 20 or more individual thin seams and interbedded sandstone and shale layers, which combine to create an attractive NGC exploration target. Gas contents are generally low in the Drumheller Coal Zone. A series of thin coal zones overlie the Drumheller Coal Zone.

The last major coal zone with thick, widespread distribution that is being targeted for NGC in the Plains is the Ardley Coal Zone of the Scollard Formation. The two areas that have been the main focus of NGC exploration in the Ardley Coal Zone are northeastern Pine Creek (north of Edson) and central Pembina (Buck Lake-Drayton Valley). These areas include some of the thickest and most continuous Ardley coals (15 to 25 metres total coal), and occur at depths between 300 and 700 metres. Gas contents are generally higher than those of the Drumheller Coal Zone.

Alberta Foothills

The Foothills include several coal zones that are correlative or equivalent to the coal zones in the Plains. Foothills coals have experienced a greater degree of coalification (see discussion below), and have higher contents of NGC than Plains coals. These coals commonly show much deformation, which disrupts their continuity and thickness.

Locating thick coals with limited deformation is a challenge in exploring for and producing NGC in the Mountains and Foothills. Currently, there is limited exploration in a few locations.

An additional coal zone is found within the Foothills of southwestern Alberta in the Kootenay Group. The Kootenay coals are currently mined in the Fernie Basin and were previously mined in the Crowsnest Pass. These coals have very high gas contents and major deformation due to the mountain building process. There is currently one project underway to further evaluate these coal resources.

COALIFICATION (COAL RANK) AND NGC GENERATION

Coal is a carbon-rich rock derived from plant material (peat) that accumulated in swamps, and was subsequently buried by ongoing geological processes. As the plant material is buried deeper and deeper, the temperature and pressure increases and the plant material undergoes coalification.

Coalification is a progressive change in the plant material that involves releasing volatile matter, including water, carbon dioxide and light hydrocarbons including methane, as the plant material begins to change into coal. With ongoing coalification, the coal becomes progressively enriched in carbon and continues to expel volatile matter. Thermal maturation (chemical changes with increasing temperature) in coals generates methane and other hydrocarbons.

Shallow coals of the Plains (i.e., Ardley, Horseshoe Canyon) have a low rank (low level of coalification), and have not generated much methane. Deeper coals (i.e., Mannville) have experienced a greater level of coalification (high rank), and have produced and retained greater amounts of methane than the shallower coals.

Some methane in coals may be produced by bacterial action (biogenic gas). Biogenic gas may be produced any time throughout the coalification process if the proper conditions are present. Neither thermogenic nor biogenic processes produce appreciable amounts of hydrogen sulphide (H_2S) from Alberta coals. Of this, only minor amounts generated are trapped in coal.

Gas is primarily held within coal by "adsorption" (or attachment) onto the coal particles. Given the right conditions, lesser amounts of gas can also be stored in coal as free gas within micropores or fractures throughout a coal bed. The pressure on the coal seam holds the "adsorbed" gas in place. Reducing the reservoir pressure allows this gas to be released from the coal.

Over the past millions of years, some gas that was generated in coal has dispersed from the coal to nearby sandstone reservoirs or into the atmosphere. This can result in some coal seams containing less gas than they did originally.

Coal Cleat—Moving NGC From the Coal to the Wellbore

Mountain building processes in the western parts of Alberta and in British Columbia (Rocky Mountains) have produced great stresses in the coal and rocks throughout the province. This stress contributed to the formation of a series of tight, closely spaced small fractures in the coal beds, referred to as "cleats". Cleat development is also controlled by coal rank and composition.

These interconnected fracture networks allow fluids (water and gas) to move through the coals and into a wellbore for production. The widths or openings of these fractures or cleats are generally wider near the surface. With increasing depth, however, the weight of the overlying rock compresses the fractures, reducing their width and interconnectivity.

Fractures and cleats may be enhanced in areas of faulting, fracturing, or where coal seams may be deformed. NGC companies are always looking for areas of enhanced fracturing to improve their exploration success potential.

Ardley coals have moderate gas contents, and generally show lesser amounts of cleating than many of the other coal zones in Alberta. Despite this, production potential is being evaluated in the Pembina area.

To date, Horseshoe Canyon coals with relatively low gas contents, but favourable cleating/fracturing, are being successfully targeted for NGC production in the south-central Plains. Mannville (and correlative) coals are showing a potentially favourable amount of cleating/fracturing and high gas contents in some locations, and are undergoing evaluation in the north-central to central Plains.

Cleating is often destroyed by shearing* in the Foothills coals, but Kootenay coals, which also contain high gas contents, are being evaluated in the southern Foothills.

**Shearing refers to deformation that occurs within a coal seam when the seam is subjected to stress.*

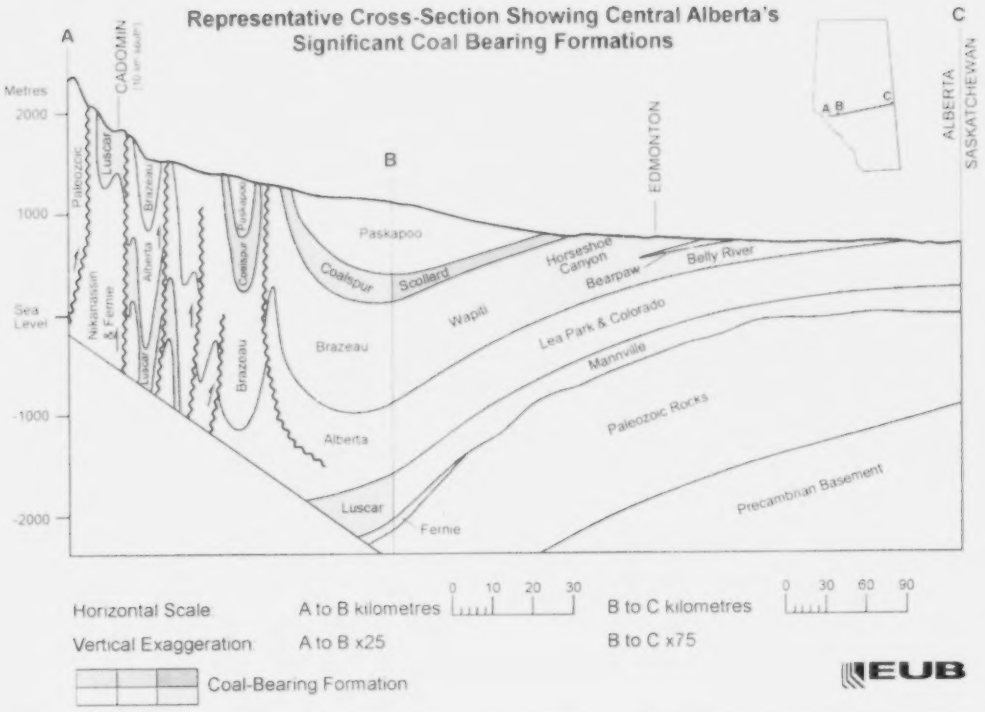

Figure 1. Representative cross section through central Alberta, showing the geometry of coal-bearing formations, in particular the gentle west dip of strata towards the Foothills, where folding and thrusting brings coals near the surface.

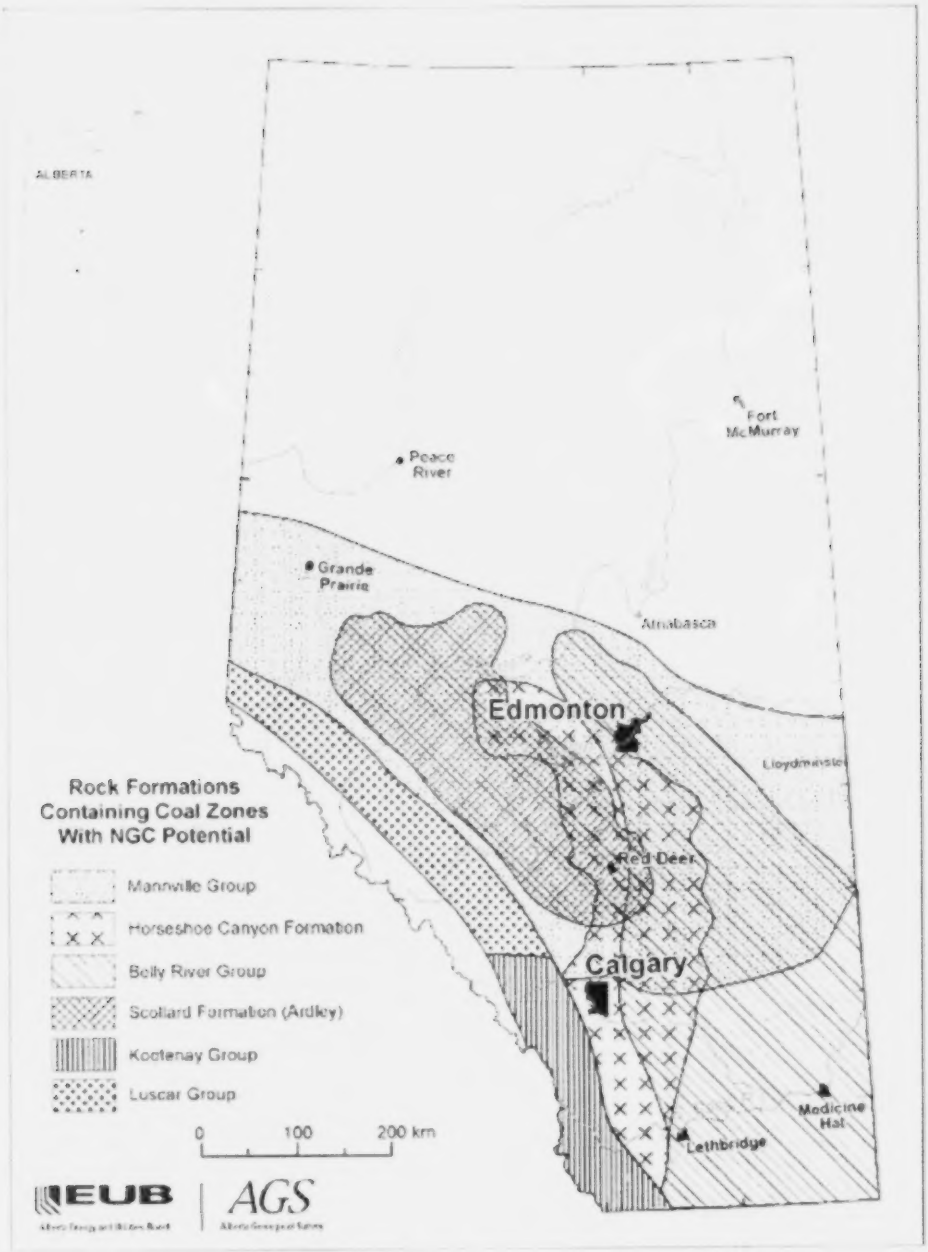

Figure 2. Distribution of coal zones across Alberta that may have NGC potential.

NGC ACTIVITY

Reporting of Information

Since NGC is a form of natural gas, all NGC wells are licensed as natural gas wells in Alberta. This means that all data, including produced fluid volumes and rates, (oil, gas and water) must be collected and reported to the EUB in the same manner as occurs for other gas wells. In addition, produced fluids must be sampled and analyzed.

Aside from certain data for the few NGC operations that have been approved by the EUB as experimental schemes (under section 39 (1) of the *Oil and Gas Conservation Act)*, all this information is public. All experimental scheme applications are public documents, and a list of all experimental projects is published by the EUB.

NGC Targets for Alberta

As part of energy development in Alberta, thousands of conventional oil and gas wells have been drilled through coal seams. This has allowed data to be collected about coal occurrences, enabling mapping of coal distribution over much of the southern half of Alberta (see page 7). This mapping has been further refined by the Alberta Geological Survey, allowing coals with the potential for NGC production to be mapped.

In general, there are three main NGC target zones in Alberta's subsurface. From deepest to shallowest, these are the Mannville zone, the Horseshoe Canyon/Belly River zones, and the Scollard (Ardley) zone. The Kootenay coals of the southwestern foothills are the subject of only minor NGC interest at present (see page 7).

Number of NGC Wells

While much of the province holds potential for NGC production, actual NGC development, production data, and related information has been very limited in Alberta until recently. Even with the current interest in NGC activity, the number of NGC wells represents only a small fraction (about one per cent - see Table 1 on page 10) of the total wells drilled annually in Alberta, and even a smaller fraction of actual Alberta natural gas production.

Reports of the number of NGC wells in Alberta have varied somewhat because there are different definitions of what constitutes a NGC well. The EUB considers a gas well a NGC well when it is licensed for, or completed in, a coal seam.

Because NGC development is in its infancy in Alberta, numbers of NGC wells have increased in recent years. In 2000, there were fewer than 50 wells drilled for NGC, while the number increased to approximately 400 by May 2003. The EUB is currently refining the tracking process for verifiable NGC wells.

Since the numbers tend to increase in spurts as projects are developed, printed tabulation of such wells is often outdated by the time they are reported. In addition, coals are often interspersed in the subsurface with other rock types that may include both conventional and other unconventional gas reservoirs.

Coal in Alberta usually occurs as a series of thin seams, compared to generally thicker coal seams found in most U.S. basins that produce NGC (e.g., Powder River Basin, San Juan Basin). For many years, it has been common for wells in Alberta to produce from both coals and sands. This complicates the ability to make a simple classification of wells as purely NGC versus other forms of conventional or unconventional gas.

Distribution of NGC wells

So far in Alberta, most NGC wells drilled (about 75 per cent) have targeted the middle Horseshoe Canyon and Belly River coal zones. Drilling in these zones has been concentrated in southeastern and east-central Alberta.

These parts of the province tend to already have existing gas and oil infrastructure. Development is often less costly in these areas, partially because of the dry nature of the coals, which means there are no water handling costs. Therefore, targeting coals in these areas for NGC development shows the most rapid growth, a trend that would be expected to continue for some time.

The next most active NGC target to date (about 10 per cent) is the deeper Mannville zone in north-central Alberta. The Mannville coals in this area are deep (over 1,000 metres) and tend to produce highly saline formation water, similar to conventional oil and gas wells at this depth.

Other NGC development involves wells in small pilot projects distributed over a broad area of west-central and southwestern Alberta. Test wells targeting the shallower Scollard (Ardley) zone in west-central Alberta have produced NGC, along with limited amounts of water that varies in quality. An even smaller number of NGC test wells have focused on the Kootenay coals in the foothills region, some wells dating back to the early 1970s.

NGC Production

Approximately 120 of the 400 NGC wells drilled for NGC to May 2003 have recorded some gas production, many with only very limited test production. Over 65 per cent of the NGC wells with recorded production have been completed in the Horseshoe Canyon and Belly River coals in southeastern and east-central Alberta (see Table 2 on page 10).

The growth in wells coming on production in these areas from these zones is by far the most significant in Alberta at present. In particular, the areas east and east-northeast of Calgary hold the greatest potential for significant near-term increases in NGC production for the reasons earlier discussed.

To put NGC well production rates in perspective, the average new gas well in Alberta has an initial gas rate of about 7.5 thousand cubic metres per day. In southeastern Alberta, where high well density development is common, new gas wells average about 2 thousand cubic metres per day. By comparison, the average NGC well in Alberta produced less than 2 thousand cubic metres per day as of May 2003.

NGC production data for the various NGC coal targets in Alberta is shown in Table 2 on page 10. Much of the data in this table is preliminary and based on limited wells, but it gives an overall indication of the early NGC production characteristics of Alberta's coals.

Table 1. The pace of NGC development in Alberta, 2000 to 2002*

Wells Drilled	2000	2001	2002
Total wells drilled for gas, oil and bitumen	**14,600**	**14,300**	**13,200**
Total wells drilled for NGC	**23**	**123**	**155**
• Scollard (Ardley) Zone	3	14	19
• Mannville Zone	5	13	27
• Horseshoe Canyon/ Belly River Zone	14	86	103
• Other**	1	10	6

*May 2003 data indicates the total number of wells drilled for NGC is approximately 400

**Includes Kootenay coals.

Table 2. Distribution and production of NGC wells (May 2003).

Formation	Number NGC wells completed	Number NGC wells with production	Cumulative Gas Production (10^6m^3)	Gas rates (10^3m^3/day)	Water rates (m^3/day)	Water Total Dissolved Solids (ppm)**
Scollard (Ardley)	26	18	7	0.1 to 6.0 (avg. 0.9)	0 to 16.5 * (avg. 0.9)	1500 – 4000
Horseshoe Canyon/Belly River	170	70	50	0.1 to 7.0 (avg. 2.6)	0 to 1.0 (avg. 0)	NA - Dry
Mannville	34	20	8	0.1 to 5.0 (avg. 0.7)	0.2 to 56 (avg. 7.0)	> 40 000

* High water production in one well may be from adjacent sands.

** ppm is an abbreviation for parts per million.

GROUNDWATER AND NGC

BACKGROUND

Water is one of Alberta's most vital natural resources. Approximately 600,000 rural Albertans depend on groundwater for their daily water requirements.

Groundwater is a major link in the hydrologic cycle. It moves continually through the subsurface, sometimes coming to the surface in the form of springs or seeps. Once on the surface, it can either return to the atmosphere through evaporation and transpiration or re-enter the groundwater system.

The flow volumes of surface water are increased by groundwater discharge during periods of drought and in winter (frozen ground conditions).

Groundwater quality changes as it moves through the subsurface. The chemical and mineral makeup of groundwater at any particular location depends on the subsurface materials it flows through. In addition, the chemistry of the precipitation (rainfall and snow) and other potential recharge waters may also affect groundwater quality.

Suitable groundwater supplies (quantity and/or quality) can be difficult to locate in some areas of the province, and expensive to develop in others. Excessive withdrawals may pull more groundwater out of an aquifer than can be naturally replenished (recharged). Over-pumping or dewatering activities are serious problems that can deplete groundwater aquifers.

Saline Groundwater

The *Water Act* defines saline groundwater as water with more than 4,000 milligrams per litre total dissolved solids (mg/L TDS). This definition helps regulators assess the suitability of the water for different uses. In general, the deeper the groundwater, the more saline it becomes.

Drinking Water

According to the *Guidelines for Canadian Drinking Water Quality*, water for human consumption should have a TDS of 500 mg/L or lower. Above this level, there may be a taste or odour issue, but not necessarily a health concern. Groundwater used for human consumption in Alberta can range up to approximately 1,500 mg/L TDS. Some livestock can tolerate up to 4,000 mg/L TDS.

The terms "potable" or "fresh" groundwater refer to groundwater suitable for drinking.

Groundwater and NGC

In some cases, water production may be associated with NGC. This production may be saline or non-saline (less than 4,000 mg/L TDS). To date, there has been little water production associated with shallow NGC production in Alberta. Saline water production has been associated with deep NGC production, such as from the Mannville Group coals, which occur at depths greater than 800 metres.

NGC AND PRODUCED WATER

Under the *Oil and Gas Conservation Act* and regulations, the EUB regulates drilling, completion, operation, and produced water disposal for oil and gas wells, including NGC wells. In addition, the regulations address groundwater protection through requirements for wellbore isolation (cemented casing across non-saline aquifers), and from potential surface sources through storage requirements, dikes, liners, etc.

Groundwater produced in conjunction with oil or gas is referred to as produced water and is predominantly saline water. In order to prevent damage to the environment, and as required by legislation, the EUB ensures all produced saline water is safely handled.

The EUB does not allow surface disposal of produced water, or disposal above the Base of Groundwater Protection (BGWP)*. Instead, industry must return this water to the subsurface, generally to the zone of origin or deeper. This is deep well disposal as per current regulations.

**(the approximate depth at which saline groundwater is encountered)*

NGC Wells and Water Authorization

Any non-saline water produced in association with NGC must be handled properly. Where the produced water is suitable for surface disposal, the EUB and Alberta Environment ensure water-handling methods are appropriate.

An authorization must be obtained under the *Water Act* to divert and use or dispose of groundwater from a target coal seam containing non-saline groundwater. This differs from saline groundwater, which must be re-injected into a deep disposal well in accordance with EUB regulations.

Alberta Environment does not authorize large-scale water diversions for any purpose without some form of prior investigation. Before an authorization is granted under the *Water Act*, acceptable technical evidence must be provided to show the proposed non-saline groundwater diversion:

- will not unreasonably impact the water supply of nearby users over the short or long-term,
- will not damage the source aquifer or other aquifers,
- will not harm the environment in general, and
- will be beneficial.

Should an authorization to divert (and use or dispose of) non-saline groundwater be granted, conditions are attached that may require production volumes to be metered, and water levels to be monitored in the target aquifer and other aquifers. Dedicated observation wells, which are completed in the target coal zone(s) and/or other specific aquifer intervals, may be required. These wells are used to monitor the effects of groundwater production and other issues that may arise, such as water quality, within the main project development area and in the area surrounding the project.

NGC wells that require authorization under the *Water Act* must also comply with the *Water (Ministerial) Regulation*. This regulation includes provisions prohibiting the co-mingling of non-saline and saline groundwater, and the co-mingling of groundwater of different quality by not allowing wells with multi-aquifer completions.

For NGC projects where the target coal zone(s) are anticipated to contain and produce non-saline groundwater, a preliminary groundwater assessment containing baseline resource inventory data and other required information, must be prepared before any diversion of groundwater (See Attachment A: Preliminary Groundwater Assessment.).

The *Groundwater Evaluation Guideline*, Part 2, Section 2.02 (pages 10 and 11) contains descriptive notes on information that must be obtained/confirmed during the field-verified survey (available on the Internet at www.gov.ab.ca/env/water/Legislation/index.cfm).

The discharge of produced water to a surface water body or drainage course is not currently permitted by the EUB. However, if produced water meets the requirements of the *Surface Water Quality Guidelines for Use in Alberta*, Alberta Environment and the EUB will discuss appropriate options.

ATTACHMENT A. PRELIMINARY GROUNDWATER ASSESSMENT

Please note: This is Alberta Environment's preliminary groundwater assessment process. It has not yet been applied to a NGC project. The following explains how an assessment for NGC would occur.

Alberta Environment is required by legislation (with the exception of household use) to review any situation where non-saline groundwater is extracted. Authorization to divert groundwater under the *Water Act* is required for any NGC operation that produces non-saline groundwater. A Preliminary Groundwater Assessment (PGA) must be prepared by the developer, prior to any drilling and diversion of groundwater, whenever the target coal zone(s) is anticipated to contain and produce non-saline groundwater, as defined by a TDS value < 4000 mg/litre.

The PGA must be submitted to the appropriate Alberta Environment regional office (list/map attached) for review to determine whether an authorization to divert groundwater is needed. A consultation with Alberta Environment staff may be necessary.

Note: This consultation should occur before well licence applications are filed with the EUB under Guide 56.

The collection of baseline groundwater resource information, prior to any subsurface investigations, is essential to identify any changes that may be attributed to the pumping of groundwater and the NGC project activities. Depending on site characteristics, it may be necessary to install dedicated observation wells in the target zone(s) and other aquifer zone(s) within the development area, as well as at some distance beyond the development (project) boundaries. Dedicated observation wells will be used to monitor the effect of groundwater production and other issues that may arise, such as water quality and gas migration.

Preparation of the Preliminary Groundwater Assessment should be under the guidance of a qualified groundwater practitioner who is a member of the Association of Professional Engineers, Geologists and Geophysicists in Alberta (APEGGA).

The **Preliminary Groundwater Assessment** should include, but is not limited to the following:

1. A description of the proposed NGC investigations, including:
   (a) A plan identifying the location of the proposed test hole, test well and exploratory well site(s), any surface water bodies, drainage courses, roads and infrastructure among other things such as town and/or village locations, etc.
   (b) Tables identifying the legal land location, well depth and completion interval, and surface elevation of all proposed NGC test and exploratory wells sites and the number and location of possible future NGC well sites, if known.
2. The results of a field-verified survey of existing water wells, springs and dugouts within at least 1 km of each of the proposed test hole, test well and exploratory well site(s) for the purpose of obtaining baseline conditions in the area. The maximum radius of the field-verified survey must appropriately reflect the scale and the potential impact of the project.
   (a) Descriptive notes outlining the information to be obtained/confirmed during the field-verified survey are provided in Part 2, Section 2.02 (page 10/11) of the "*Groundwater Evaluation Guideline*" available at: *www3.gov.ab.ca/env/water/legislation/guidelines/index.cfm*
   (b) For NGC investigations, it is necessary to confirm with the well and/or property owner(s) the existence of gas in any water well(s). Their concerns about the proposed investigations and the potential project development should be recorded. Potential users of the produced water should be inventoried.

3. A description of the general geology, including plans, cross-sections and tables identifying, but not limited to:
   (a) The identification of geologic formation(s) and target coal seam(s) by name, if applicable.
   (b) The depth and thickness of the target coal seam(s), and thickness and type of material immediately above and below the target coal seam(s).
   (c) The relationships between the depth/elevation of the target coal seam(s) and the Base of Groundwater Protection.
4. A description/discussion of the hydrogeologic conditions in the area, including but not limited to:
   (a) Hydrogeologic cross-sections illustrating the geologic formations and the depth, thickness, elevation, continuity of the target coal seam(s) in relation to the Base of Groundwater Protection and other aquifer units.
   (b) The depth, completion interval and non-pumping water level of area water wells relative to the depth of the proposed test hole; and completion interval of all test well(s) and/or exploratory well site(s) and the depth to the Base of Groundwater Protection.
   (c) The anticipated groundwater withdrawal rates, volumes and groundwater quality from the coal seam(s) and the potential for cross-flow between the target NGC zone and adjacent aquifer units.
   (d) The drilling method(s), fracturing method, fracturing fluid, chemicals, etc., that may be used, among other things, during the proposed investigation and well completion program.
   (e) The proposed method of produced-water disposal.

The provisions in the *Water (Ministerial) Regulation* prohibit co-mingling of non-saline and saline groundwater and co-mingling of groundwater of different quality by not allowing multi-aquifer completions. The regulations prohibit well completion intervals of greater than 7.62 metres unless a distinct aquifer unit of greater thickness is present.

The discharge of produced water to a surface water body or drainage course is not currently permitted by the EUB. However, if produced water should meet the requirements of the *Surface Water Quality Guidelines for Use in Alberta,* Alberta Environment and the EUB would be prepared to discuss appropriate options.

More detailed information will be required at the authorization stage. Attachment B provides an outline of the "Detailed Groundwater Evaluation for Authorization Purposes".

ATTACHMENT B. WATER ACT APPLICATION SUPPORTING DOCUMENTS

Information in the Preliminary Groundwater Assessment (PGA) forms part of the technical information submitted in support of an application for an authorization under the *Water Act* for diverting groundwater for the production of NGC.

A technical report will be required for submission to the appropriate regional office (see attached map and list of regional office locations). The report will supplement the PGA, and should contain the following:

1. An overview of existing geologic and hydrogeologic information available for the general area and the results from a field-verified survey of all area water wells.

   Information on area water supplies shall be discussed in the report requesting authorization to divert (and use) groundwater from coalbed(s) containing non-saline groundwater. Specific water well information gathered during the survey shall be presented in the report on plans and tables identifying, among other things, the legal land location, the owner's name, well depth, non-pumping level (and date), completion method and interval, and the composition of gas, if present in the wells. Additional tables, if required, shall provide a summary of historic chemical analyses. Please ensure that information collected for the PGA remains current when submitting the detailed groundwater evaluation.

   Historical water well records are available at www.gov.ab.ca/env/water/groundwater.

2. Discussion of the drilling program by documenting information related to the test holes, test and production wells and observation well installations.

   The locations of all test holes, test or production and observation wells shall be shown on a plan, and table(s) showing the well completion. Other relevant data shall be provided in the report. The number of observation wells installed during the investigation program depends on the site-specific aquifer characteristics and the need to evaluate the ongoing effects of groundwater production within and adjacent to the development area. Lithologs and geophysical logs indicating the aquifer zones of all holes drilled during the investigations shall be provided in the report.

3. Testing and determination of the aquifer parameters.

   Pumping tests are commonly conducted to assess the aquifer parameters at the project site. A pumping test normally consists of pumping a well at a constant rate for a specific period of time, followed by a similar recovery period, during which time the water level is measured in the pumped-well and one (1) or more observations wells. The pumping test data are assessed to determine the aquifer parameters and the sustainable rate at which groundwater can be withdrawn from the aquifer without causing aquifer depletion or unreasonable impact to other aquifers or groundwater users in the area.

   *Note: There shall be **NO** diversion from any well(s) following the testing period without formal authorization under the* Water Act.

4. Water quality and gas characteristics.

   Water quality samples shall be collected and analyzed to determine the background water quality in the area coal seam aquifer(s), and other selected aquifer units. Diversion of non-saline groundwater, based on a TDS < 4000 mg/L, requires authorization under the *Water Act*.

   If gas is present in the water wells, a sample should be collected and analyzed to establish baseline conditions.

5. Public notification.

   Public notification will be required after the application is deemed complete to the Director's satisfaction. Statements of Concern can be submitted within one (1) month of the public notice. Local Statements of Concern shall be considered prior to granting an authorization for long-term groundwater withdrawals under the *Water Act*.

6. Groundwater availability assessment and monitoring of the expected cone of depression water levels.

   Groundwater availability and the rate of water level decline or recovery within the cone of depression is dependent upon the aquifer parameters, the rate of withdrawal and the pumping period. The heterogeneous nature of the target coal seam(s) may promote irregular patterns of drawdown within the project area as a result of lenticular and hydraulic connectivity with overlying units.

   Long-term monitoring of water level fluctuations from the target coal aquifer, and other aquifers, will verify the predicted response and/or provide an early warning of any unexpected impacts as a result of pumping.

7. Mitigation of undesirable impacts.

   The identification of water wells, their completion interval, water level and water quality within the expected cone of depression will help determine if the proposed groundwater withdrawal has the potential to affect area water supplies. Methods of mitigating the potential unreasonable interference with existing wells and other aquifers that may experience quantity or quality changes attributable to the diversion of groundwater from the target coal zone, shall be identified through the testing, monitoring and evaluation program.

8. Monitoring recommendations.

   Monitoring requirements should take into consideration the area residents' concerns about the potential for water level decline and water quality change. Monitoring of water levels in neighboring wells and/or dedicated observations wells allows the public and Alberta Environment the opportunity to ensure the withdrawal occurs in an acceptable manner and that existing groundwater users are able to maintain their water supplies. Background water quality parameters for the target coal seam(s), and other aquifer units, can be established during the initial investigation program. Possible changes in water quality as a result of the diversion may be identified by the conditions attached to the authorization.

9. Reporting.

   Conditions attached to the *Water Act* authorization(s) will identify the specific reporting requirements with respect to the frequency of metering production, measuring water level and the submission of current water quality analyses. Authorization conditions will vary due to the site-specific nature of each project.

10. Abandonment.

    Test holes and all wells drilled for the purpose of investigating, evaluating or producing natural gas reserves within coal seams shall be abandoned in accordance with the respective EUB regulation.

11. Questions.

    Proponents should contact Alberta Environment staff if they have any questions regarding the procedure on matters related to the application for an authorization under the *Water Act*.

Note: Any expansion to the original work plan would require updated information and a new authorization.

ALBERTA ENVIRONMENT

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200, 3115 - 12 Street, NE
Calgary, Alberta T2E 7J2
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SURFACE ISSUES

All energy developments can have some degree of impact on the local area, surrounding environment and nearby public. Surface impacts can result from the direct energy development activity (e.g., wells, pipelines, facilities), as well as from associated infrastructure (e.g., roads) and operations (e.g., noise, traffic, flaring and servicing).

INDUSTRY OBLIGATIONS

In addition to government regulation, industry has numerous obligations to fulfill in resource development. These include:

- Good industry practices (e.g., well-site selection that considers land use and type, use of innovative technology such as directional drilling, and sharing regional facilities to reduce development of unnecessary infrastructure).
- Industry recommended practices to further mitigate local impacts.
- Requirements to disclose the details and potential impacts of proposed projects to the public and other government groups to identify local needs and opportunities to further enhance or integrate proposed projects.
- Provide as much detail as practical at each stage of development to ensure the scope and potential impacts of the project can be understood clearly and piecemeal proposals are avoided.
- Carry out appropriate environmental assessments. The level of detail will vary depending on the stage of development and public needs.
- Carry out thorough and effective public consultation programs that are appropriate to the scale of the project, and that are matched to the region's sensitivity and interests of the community.

Some existing technologies may have technical or economic limitations that could limit their use in certain coal seams. However, industry is expected to continue researching new technology and ways to further mitigate impacts.

Companies are encouraged to consolidate their plans and activities with other operators to the greatest degree practical in order to reduce surface impacts. This is especially important when working in the Eastern Slopes and other environmentally sensitive areas, and where public concern has been expressed regarding surface impact in an area.

NGC PRODUCTION

NGC development will use the same equipment and conduct similar operations as conventional natural gas development. While there may be some differences, it is expected that many of the surface issues, including potential impacts on the public and the environment, will also be similar.

Number of Wells and Wellsite Locations

In much of Alberta, particularly in areas of shallower natural gas development, two to four gas wells per section per pool are common. Where necessary, higher density gas development exists to effectively recover the gas. Initial information suggests the spacing for wells targeting a coalbed source may be two to eight wells per section per pool. This will depend on various factors, especially the area's geology.

Industry must file an application with the EUB to reduce well spacing from pre-set standards. Such applications include requirements for public consultation. Early public involvement in spacing applications, prior to identifying all project details or individual well locations, is useful in identifying broad development plans

and special needs. These can then be addressed in subsequent site-specific well or facility applications.

In areas already producing conventional oil or gas, NGC development may be able to use the existing infrastructure as a way of minimizing surface impact and disturbance. This includes drilling multiple wells from a single surface location, to reduce surface disturbance while allowing the necessary number of subsurface wells to penetrate the coal seam and recover the gas. There may be some technical and economic limitations on applying such practices to shallow wells and wells pumping water.

Surface Operations and Footprint

Industry has made several innovations in new technology to minimize industrial footprints. As well, smaller well pad sites and directional drilling to allow multiple wells from a single site can also minimize the surface impact, given the limitations described above.

If pad drilling is used to reduce the overall footprint, then surface operations at the pad may be larger than would occur at a single well site; however, fewer individual sites would be required.

Routing of access roads and their frequent use by industry can also be a source of concern. When discussing project plans with Alberta Sustainable Resource Development, local authorities and landowners; NGC developers are expected to apply good land use planning practices, including careful route selection, and seek ways to align energy access roads with other industry needs. Often, existing energy facilities, suspended wells, rights of way and roads can be re-used to minimize capital investment and reduce surface impacts.

All development associated with NGC should be planned using an integrated approach. In this way, the links and advantages of using pad development, for example, will reduce the need for access roads and reduce the overall or cumulative impact.

Farming is often re-established over most of a gas lease, and a common sight would be a normal wellhead surrounded by a cattle control fence/equipment guard. At the production stage, there is generally either a low profile access road, or no road access (aside from what is needed for periodic well servicing).

Surface equipment at a NGC well may be very limited if no water is produced. If water is produced, a water storage tank may be used on site. Usually a water pipeline from the storage tank to a central facility will be used after initial well testing to reduce operating costs and eliminate impacts from water trucks and costs to build higher-grade access roads.

In compliance with the *Pipeline Act* and regulations, and Canadian Standards Association (CSA) standards, pipelines are constructed and operated using measures to control corrosion and minimize the risk of spills.

Non-toxic drilling fluids should be used to protect groundwater aquifers from contamination during shallower drilling stages of all wells. Disposal of drilling fluids is regulated by the EUB (see *Guide 50: Drilling Waste Management*).

Compression and Noise

Some degree of compression is normally required for natural gas production over the producing life of a pool, owing to the declining pressure within the pool caused by fluid withdrawals and the need to deliver gas to higher pressure facilities or pipelines. NGC wells, which generally encounter low-pressure reservoirs, will normally require compression throughout their entire production lives. This compression may be located at the well site, but more often may be located in a centralized location serving multiple wells.

Compressors vary in size, and their installation must be approved by the EUB if the total on site power exceeds 75 kilowatts (100 horsepower). (See *Guide 56: Energy Development Application Guide*.)

Compressors may be a source of noise and may cause concern to local residents if the appropriate mitigative measures are not used. Noise associated with compression in Alberta is regulated by the EUB (see *Guide 38: Noise Control Directive – User Guide*).

Public Review

When new energy projects are proposed, industry, regulators and the public must review the impact on current and future land use. Public discussions on specific project plans and options are usually needed to fully understand and address impacts.

All reasonable efforts must be made by an energy development proponent to mitigate impacts, align development with any approved regional strategies or resource plans, and manage concerns about land fragmentation and other local impacts.

The application requirements and processes, including a pre-application consultation with parties who may be directly and adversely affected by a proposed energy development, are outlined in EUB's *Guide 56: Energy Development Application Guide and Schedules* and *Guide 65: Resource Applications for Conventional Oil and Gas Reservoirs.*

FLARING AND VENTING

Background

Natural Gas in Coal is generally pure methane, with only minor amounts of carbon dioxide and nitrogen. It contains no hydrogen sulphide (H_2S) and is, therefore, considered "sweet" gas. Essentially, the composition of gas from NGC is the same as the gas used in furnaces for home heating.

Flaring is the burning of natural gas that cannot be conserved. Venting is the release of natural gas to the atmosphere where conservation or flaring is not practical. NGC does not contain heavy hydrocarbons, so its flaring or venting does not result in harmful pollutants, such as polycyclic aromatic hydrocarbons (PAHs), and other products associated with incomplete combustion.

Flaring and venting of natural gas have been significantly reduced in recent years. Efforts by the Alberta government, the petroleum industry and the Clean Air Strategic Alliance (CASA) have led to these reductions.

Regulatory Process

The development of NGC, including flaring and venting, is subject to the same extensive set of regulations that pertain to all other natural gas development. Of particular importance in regulating flaring and venting in Alberta are EUB *Guide 60: Upstream Petroleum Industry Flaring, Incinerating, and Venting* and EUB *Guide 56: Energy Development Application Guide.*

Consultation

Before flaring or venting occurs, industry must notify the appropriate EUB field office. If flaring is to continue longer than four hours, residents living within 1.5 kilometres of the well must be notified. Venting cannot occur within 500 metres of a residence unless it is approved by the EUB and the resident gives consent.

Venting

Limited venting may be permitted during initial well cleanup and testing if the volumes are not enough to support combustion. Once the volumes of gas produced are sufficient to maintain combustion, the released gas must be burned (flared). The amount of gas vented from NGC wells is expected to be very limited.

Flaring

Flaring is permitted under strict controls, according to the methods outlined in the EUB *Guide 60.* Where pipeline infrastructure is available, testing into pipelines is encouraged.

The main criteria used to determine if flaring should occur is a standard economic test that evaluates whether the produced gas volumes are economic to conserve.

It is expected that most NGC wells that produce low water volumes should be able to limit their initial flaring to short periods of time, particularly if they are close to existing oil and gas facilities.

Other wells, such as those initially producing larger quantities of water and low volumes of gas, or those far from a suitable pipeline, may require longer periods of test flaring before being shown to be economic to tie into a pipeline. In these cases, it may be necessary to flare low volumes of gas for an extended period, possibly a number of months.

Flaring associated with NGC is generally more common for the first few wells in an area until broader development occurs, or the area is considered to be uneconomic to develop. Once such development occurs, however, the need to flare decreases owing to the more extensive infrastructure available for tying in wells at an earlier stage.

Measurement

All fluids (gas and liquids) produced during venting or flaring operations must be measured and the volumes reported as described in EUB *Guide 7: Production Accounting Handbook*, and *Guide 60*.

LEGISLATION AND REGULATORY TOOLS

BACKGROUND

Various legislation, regulations, codes of practice, policies and guidelines govern energy development in Alberta. Copies are available from the Queen's Printer at: www.qp.gov.ab.ca

Some of the legislation includes:

- *Energy Resources Conservation Act*
- *Environmental Protection and Enhancement Act (and Regulations)*
- *Forests Act*
- *Forest and Prairie Protection Act*
- *Mines and Minerals Act*
- *Oil and Gas Conservation Act (and Regulations)*
- *Pipeline Act*
- *Public Lands Act*
- *Soil Conservation Act*
- *Surface Rights Act*
- *Water Act (and Regulation)*
- *Wildlife Act*

Integrated Resource Plans and other regional policies and strategies also guide development of energy resources such as NGC.

Guidelines/Directives/Information Letters

The Alberta government also produces guidelines, directives and informational letters that pertain to the development of energy resources, including NGC. For further information, visit these links:

Alberta Agriculture, Food and Rural Development

- Farmers' Advocate
  www.agric.gov.ab.ca/$department/deptdocs.nsf/all/ofa2621

Alberta Energy

- Natural Gas (includes NGC)
  www.energy.gov.ab.ca/com/Gas/NGC/

Alberta Energy and Utilities Board

- Guides, directives, informational letters
  www.eub.gov.ab.ca/BBS/requirements/
- Statistical report series
  www.eub.gov.ab.ca/BBS/products/catalog/statseries
- EnerFAQs
  www.eub.gov.ab.ca/BBS/public/EnerFAQs/default.htm
- Alberta Geological Survey
  www.ags.gov.ab.ca

Alberta Environment

- Integrated Resource Management
  www.gov.ab.ca/env/irm
- Water Management
  www.gov.ab.ca/env/water/Legislation/index.cfm

Alberta Sustainable Resource Development

- Fish and Wildlife
  www.gov.ab.ca/srd/fw/index.html
- Public Land Management
  www.gov.ab.ca/srd/land/
- *Public Lands Operational Handbook*
  www.gov.ab.ca/srd/land/lad/dl_li.html
- Species at Risk
  www.gov.ab.ca/srd/fw/escc/aeslist.html
- Surface Rights Board
  www.srd.gov.ab.ca

Other

Clean Air Strategic Alliance (CASA):
www.casahome.org

Committee on the Status of Endangered Wildlife in Canada (COSEWIC):
www.cosewic.gc.ca

Environment Canada:
www.speciesatrisk.gc.ca

Health Canada:
www.hc-sc.gc.ca/hecs-sesc/water/index.htm

Special Areas Board:
www.specialareas.ab.ca/